CFSv2 Reforecasts: Where is the Observation in the Forecast Ensemble Space?

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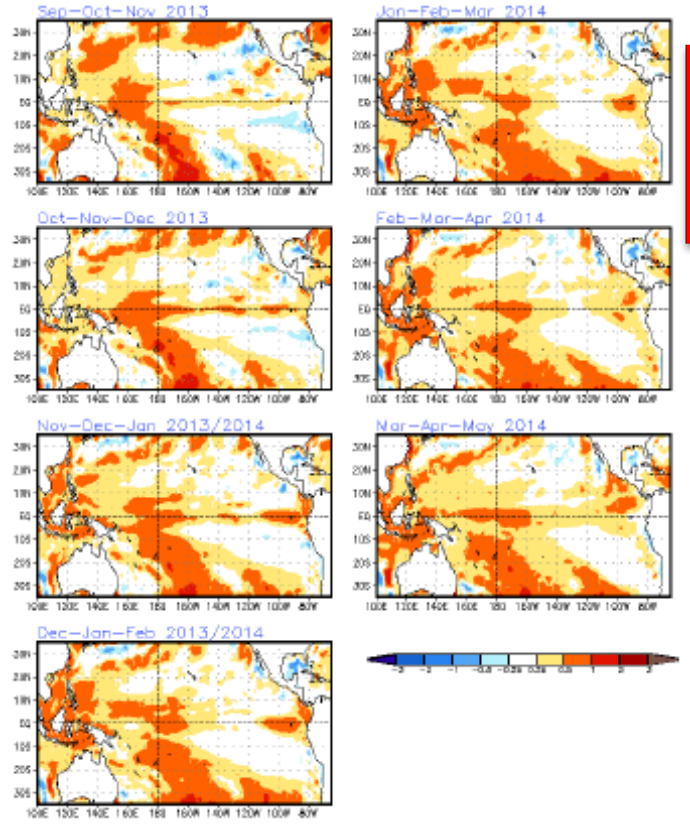
Overview

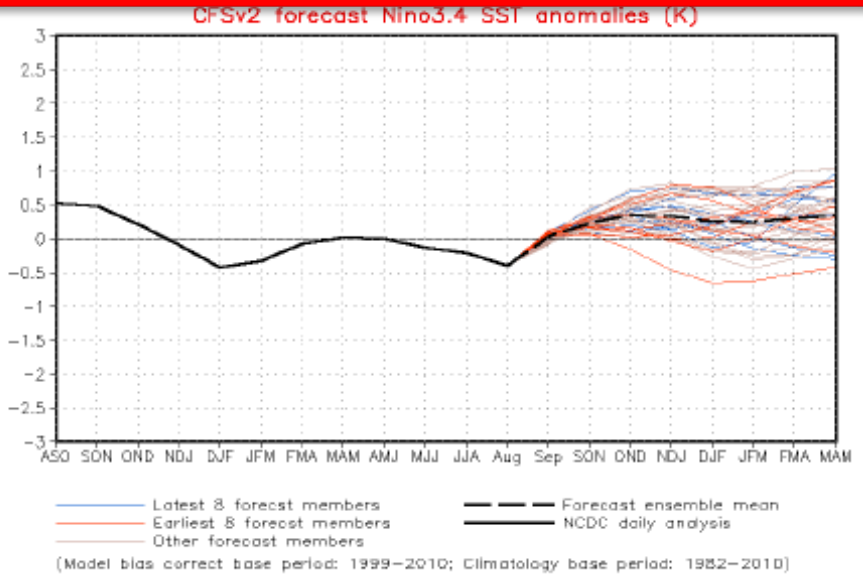
- ❑ Motivation and Objective
- ❑ Anomaly Calculations
- ❑ Systematic errors
- ❑ Answer to the title question
- ❑ Seasonality in Forecast spread
- ❑ Conclusions

Motivation: 2014 ENSO Forecast

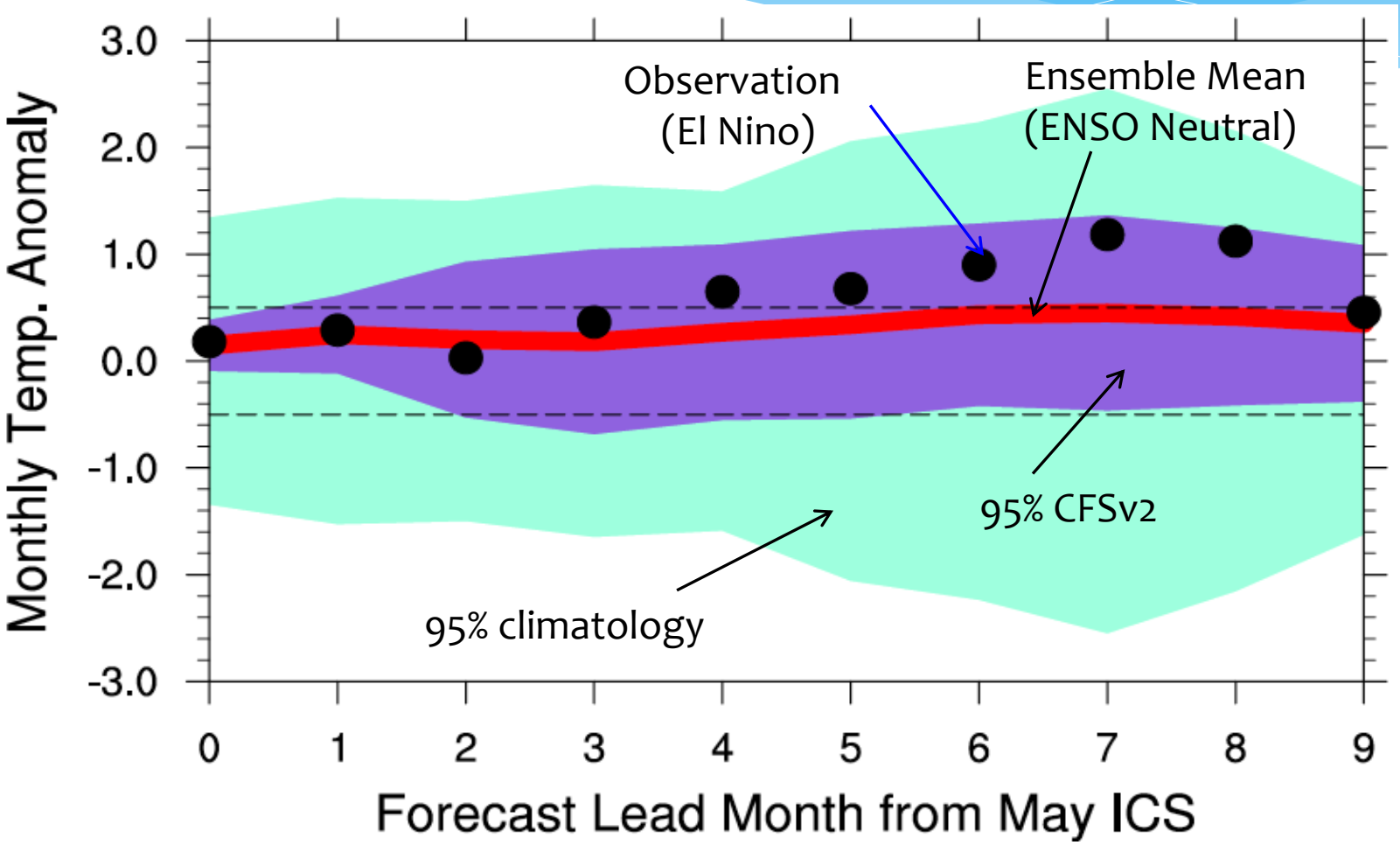
SST Outlook: NCEP CFS.v2 Forecast Issued 8 September 2013



The CFS.v2 ensemble mean (black dashed line) predicts ENSO-neutral conditions into early 2014.

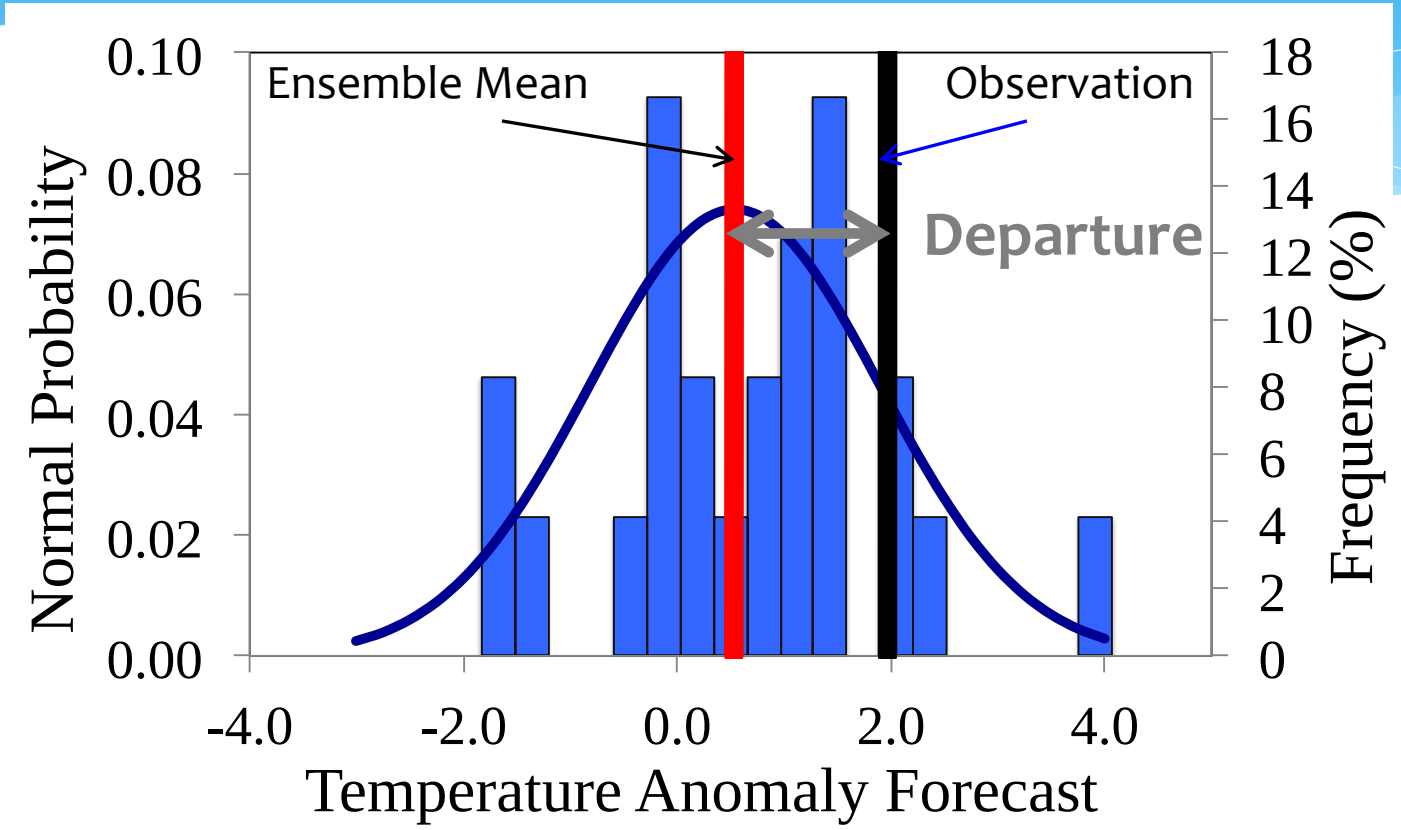


Motivation: 2006 ENSO Forecast



24-member SST anomaly forecast in Nino3.4 region using May initial conditions in 2006

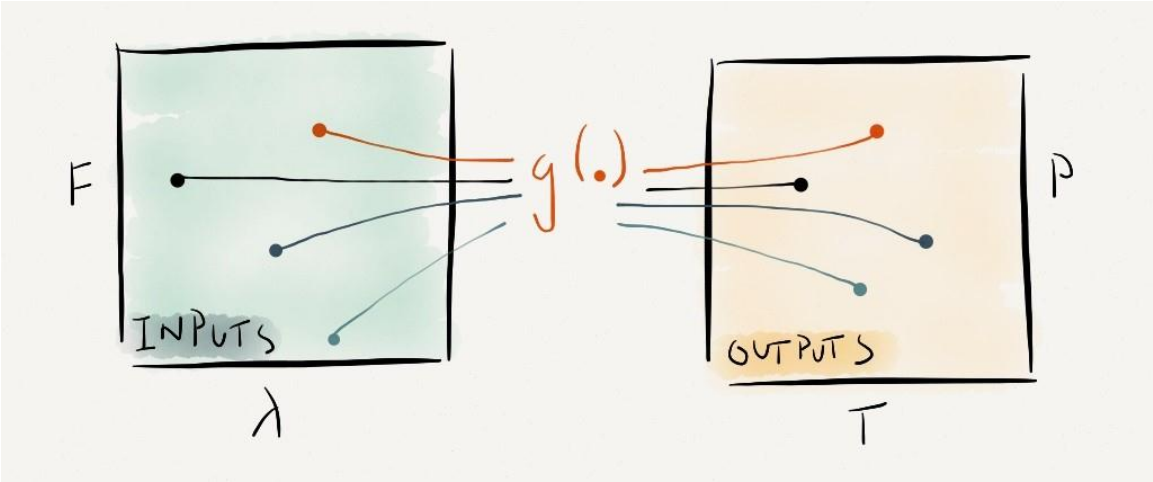
Objective: Quantify departure of ensemble mean from observation



Two Month Lead (July, 2006) Temperature Forecast in the Midwestern United States using May 2006 initial condition

Perfect Model Framework

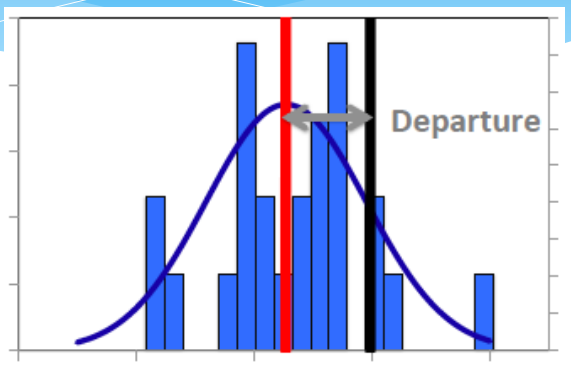
- Observations => CFSv2 Reanalysis data
- No issue of observational uncertainties and deficiency in model parameterization
- Gives an upper bound of predictability in the climate system



Anomaly Calculations

1. Absolute Departure (AD)

$$AD_{m,l,y} = \frac{abs\left[\frac{1}{n}\sum_{i=1}^{n} f_{i,m,l,y} - O_{m,l,y}\right]}{s_{m,l,y}}$$



Forecast (*f*, *n* ensembles) initialized in month (*m*) and year (y) verified at lead month (*l*) against observation of the corresponding month ($O_{m,l,y}$). $\sigma_{m,l,y}$ is one standard deviation ensemble spread

2. Absolute Anomaly Departure (AAD)

$$AAD_{m,l,y} = \frac{abs\left[\frac{1}{n}\sum_{i=1}^{n} fA_{i,m,l,y} - OA_{m,l,y}\right]}{s_{m,l,y}}$$

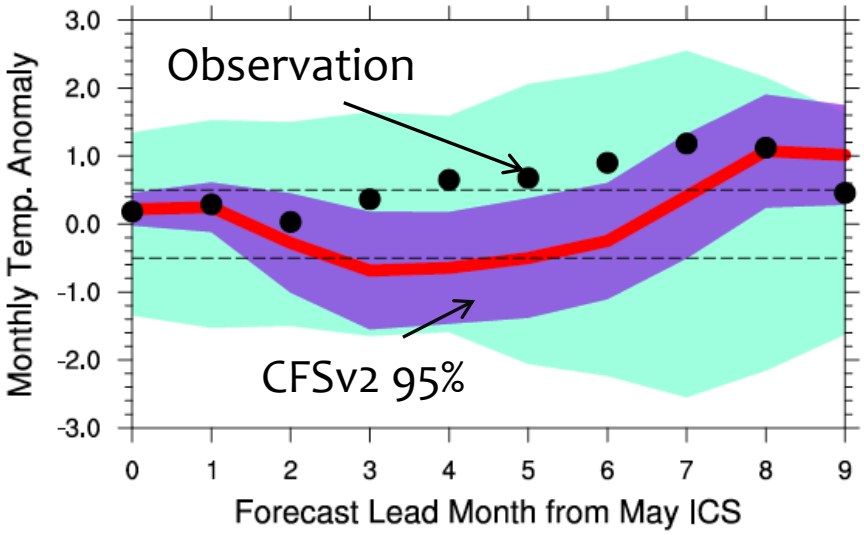
$$fA_{i,m,l,y} = f_{i,m,l,y} - \frac{1}{p}\sum_{y=1}^{p}\left[\frac{1}{n}\sum_{i=1}^{n} f_{i,m,l,y}\right]$$

$$OA_{m,l,y} = O_{m,l,y} - \frac{1}{p}\sum_{y=1}^{p}\left(O_{m,l,y}\right)$$

P is total number of years for which reforecasts are available (1982 to 2009)

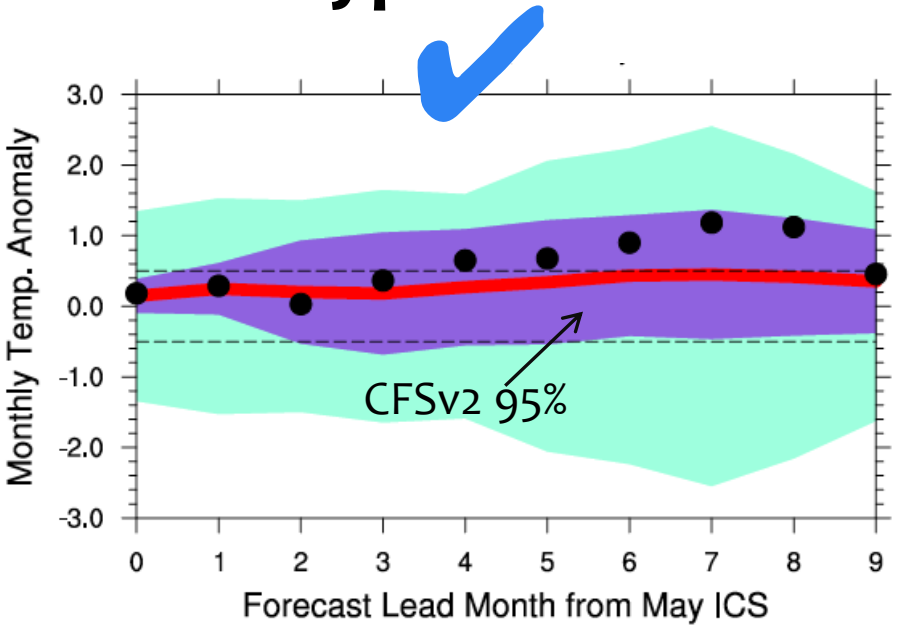
AD versus AAD Forecast

AD type forecast



4 out of 9 observations are outside 95% range

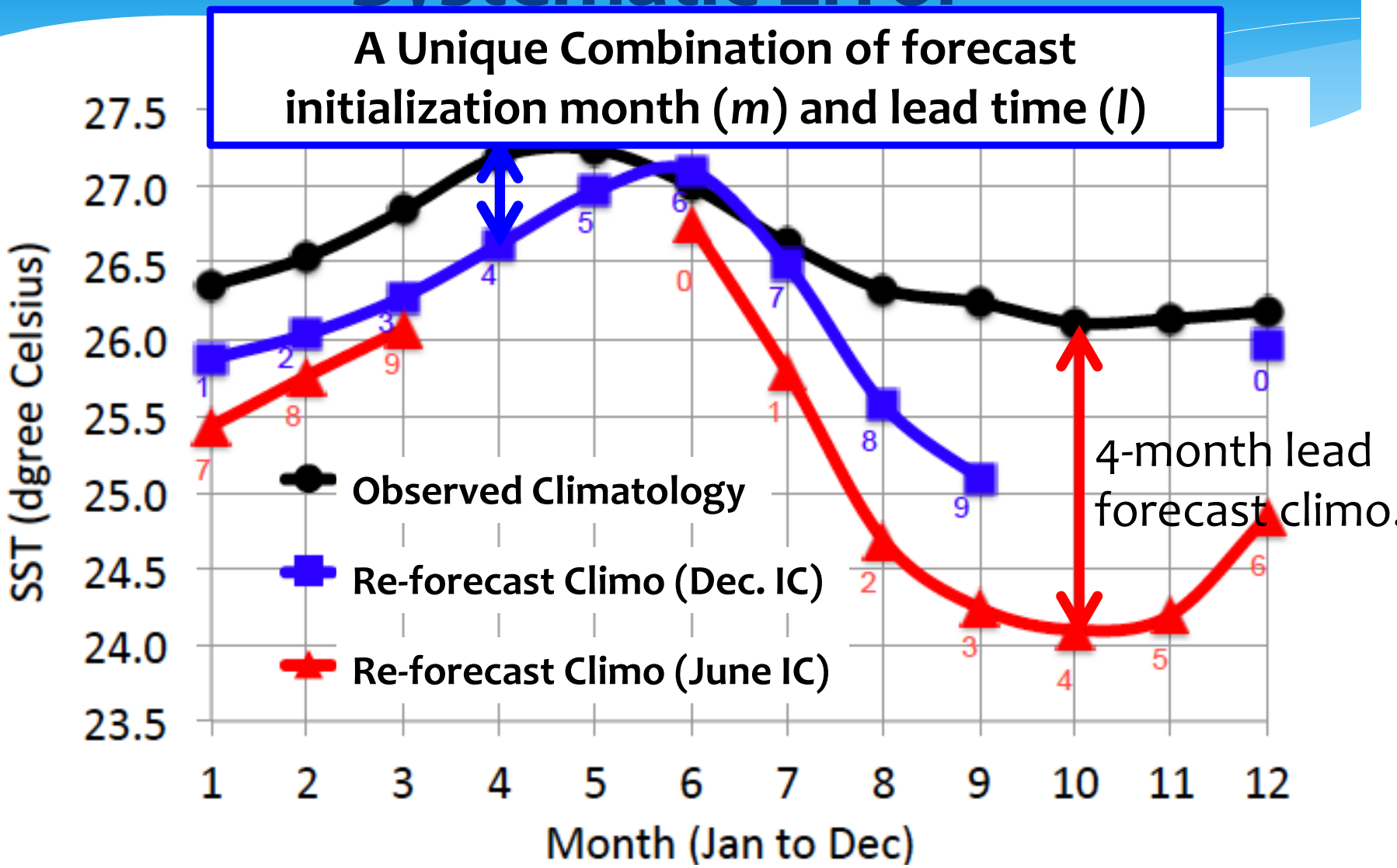
AAD type forecast



All 9 observations are within 95% range

24-member (n) SST anomaly forecast in Nino3.4 region using May (m) initial conditions in 2006 (y)

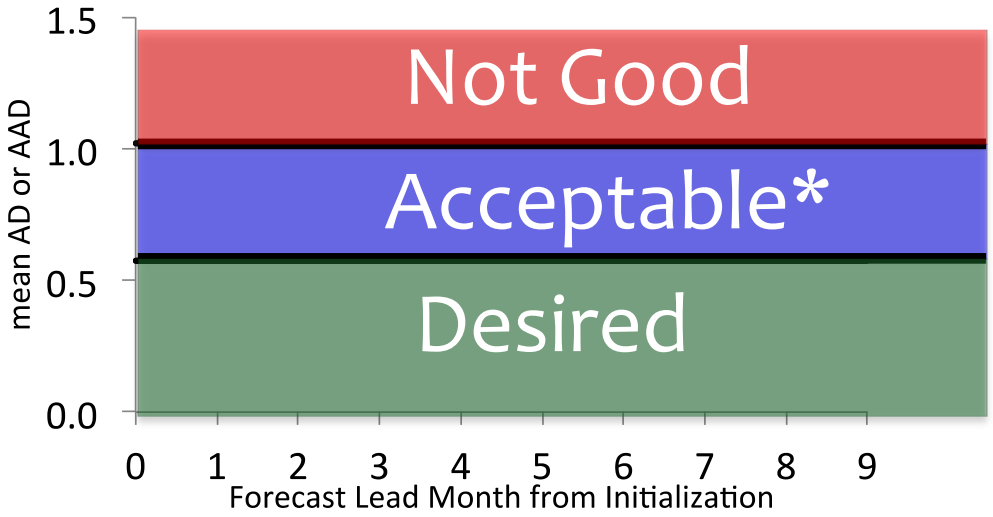
Systematic Error



SST Climatology in Nino3.4 region

Statistical Inference of Anomaly Calculations

- y = AD or AAD, y = 0 indicates observation = ensemble mean (desired outcome). For any other values y always increases
- Null Hypothesis (H0): Observation is randomly distributed around the ensemble mean (white noise: $\mu = 0$, $\sigma = 1$)
- From standard method, y is a half normal distribution with $\mu = 0.80$ and $\sigma = 0.60$. Hence 95% confidence interval for hypothesis testing can be constructed using test statistics $\overline{y}$,



* Provided forecast also mentions about ensemble spread in addition to ensemble mean (a two parameter model)

Results: mean AAD for near surface air temperature (1982 to 2008)

Average of forecast initialized in JJA months

0 month lead

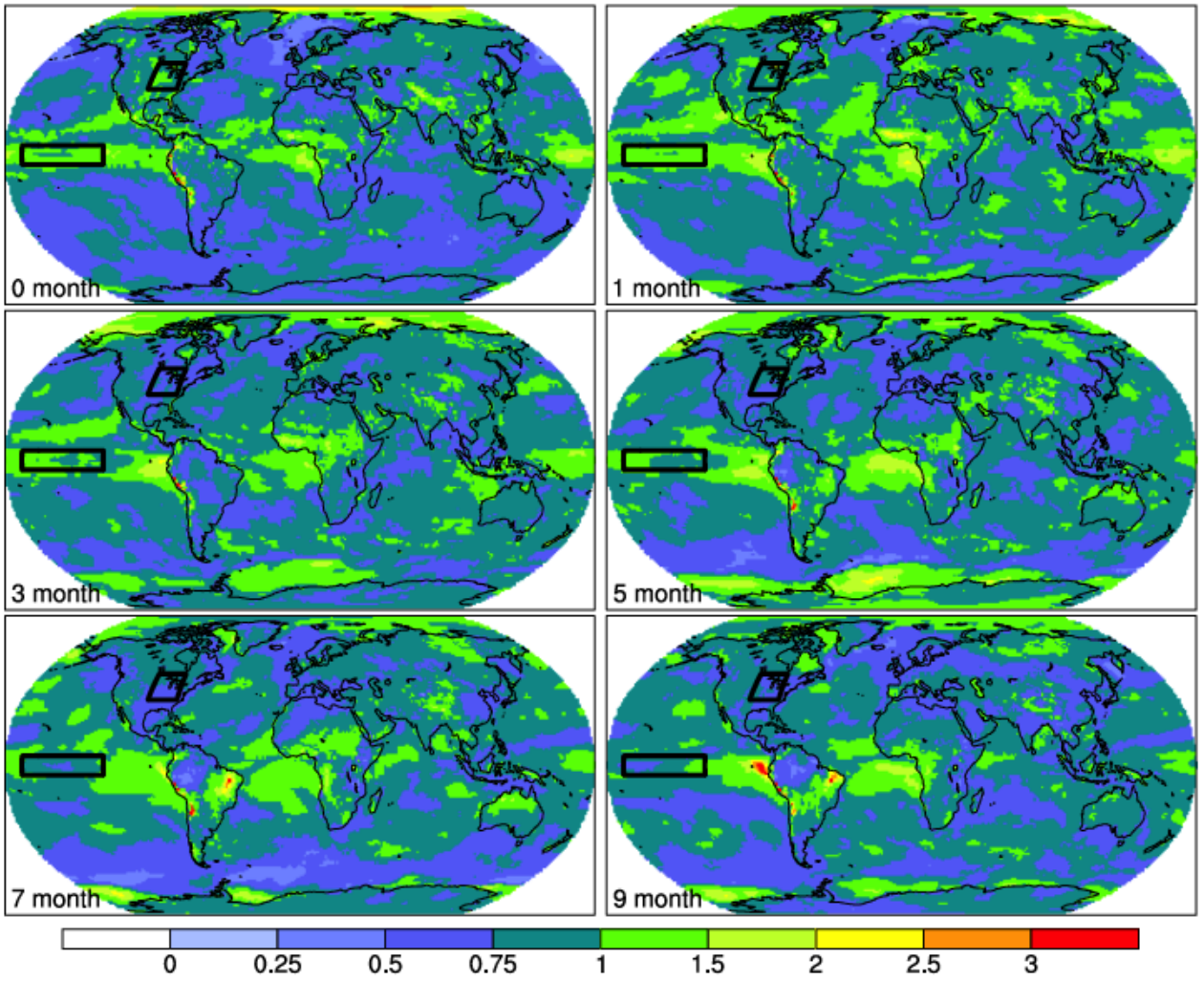
1 month lead

3 month lead

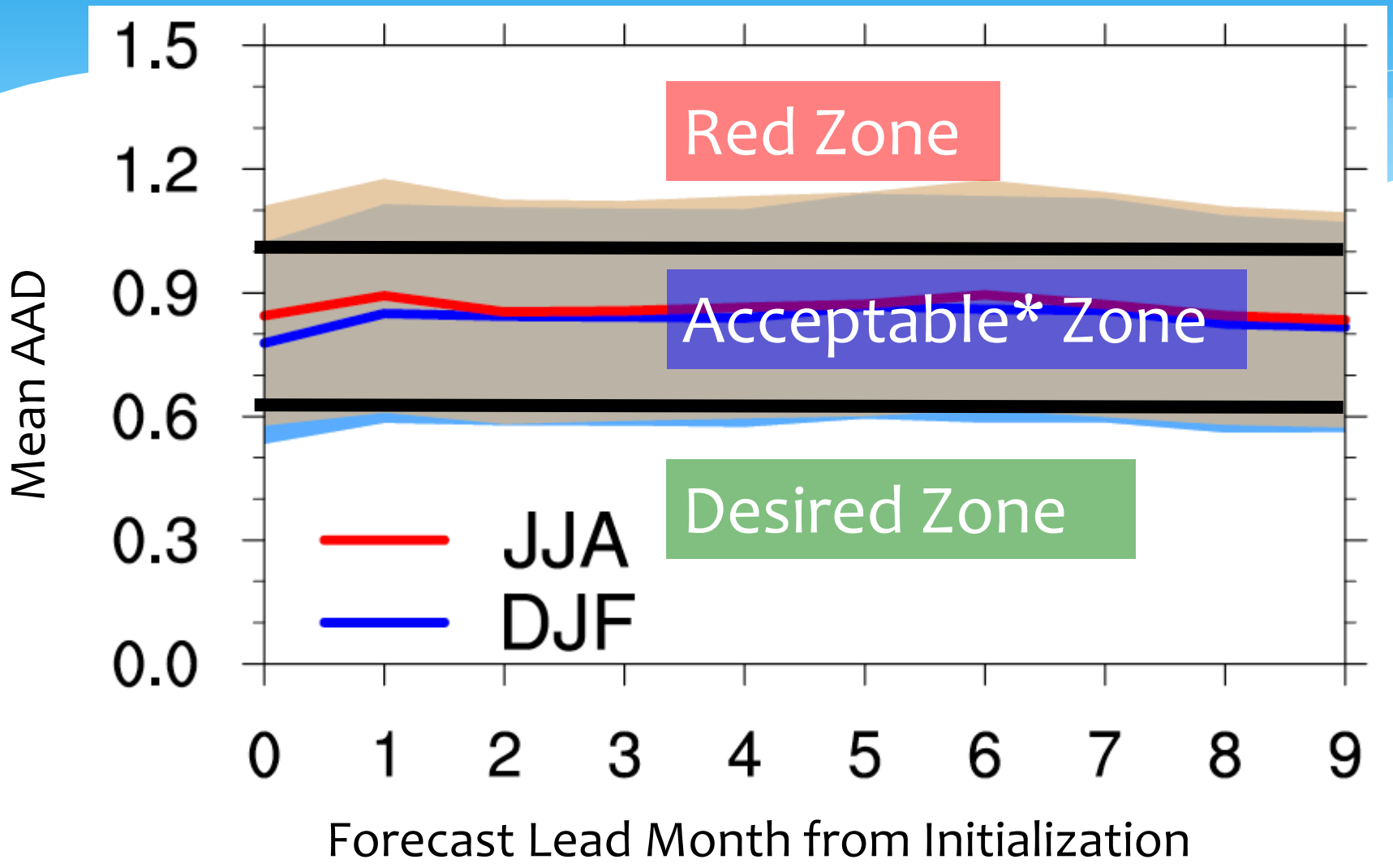
5 month lead

7 month lead

9 month lead

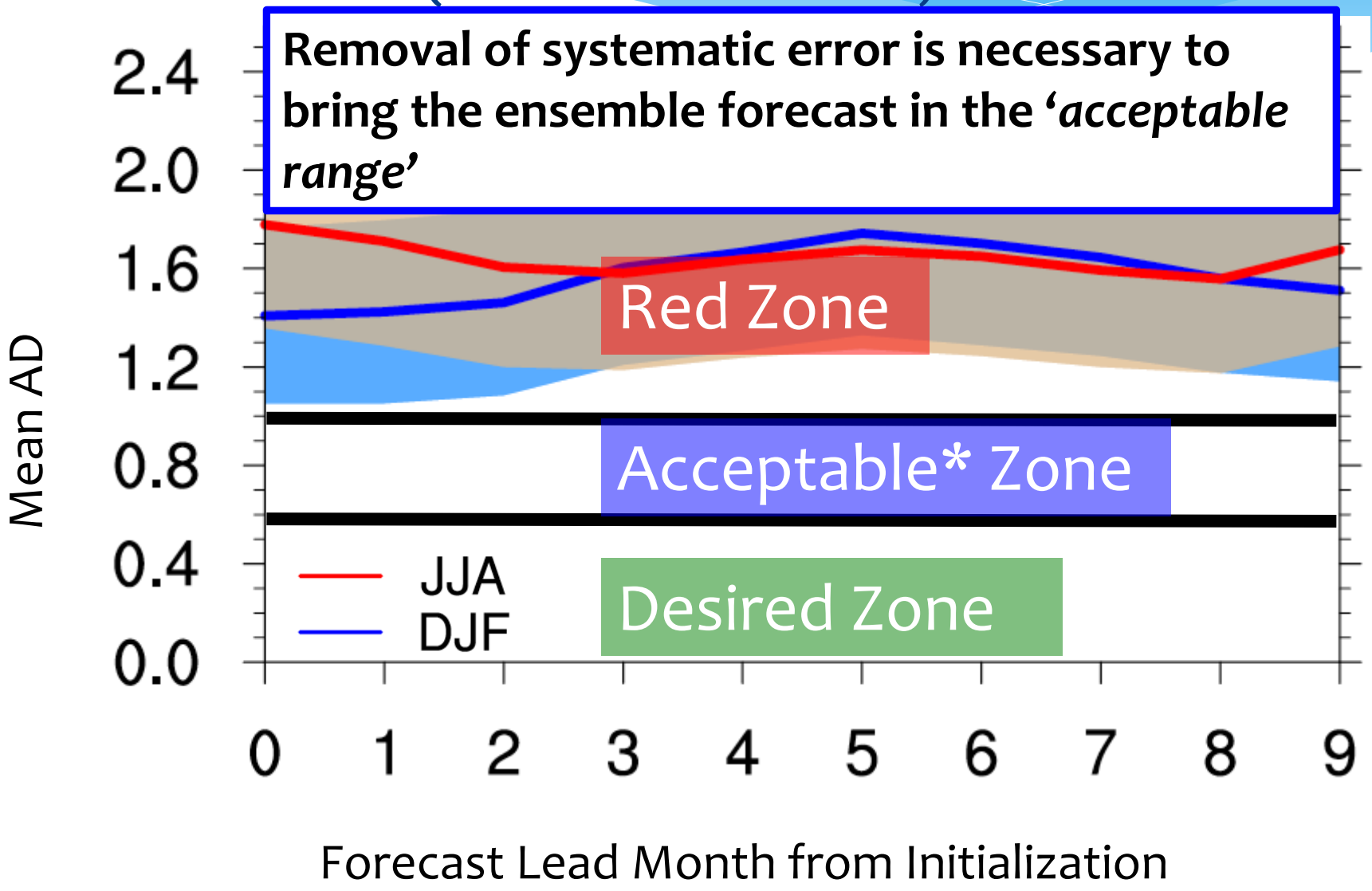


Global Land average mean AAD for near surface air temperature (1982 to 2008)



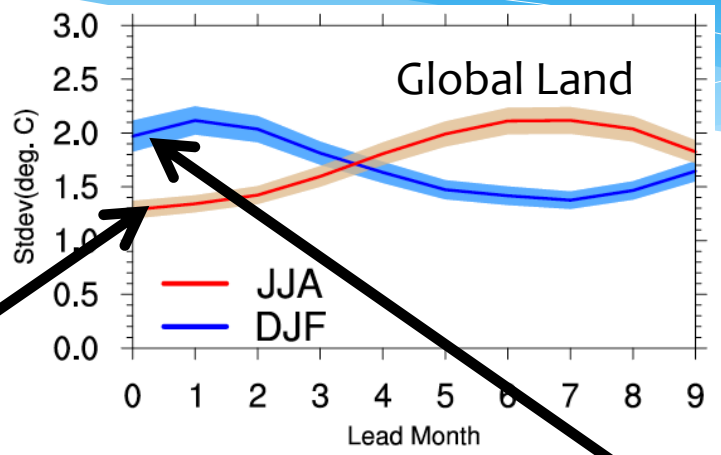
Difference between AD and AAD

(same as last slide for AD)

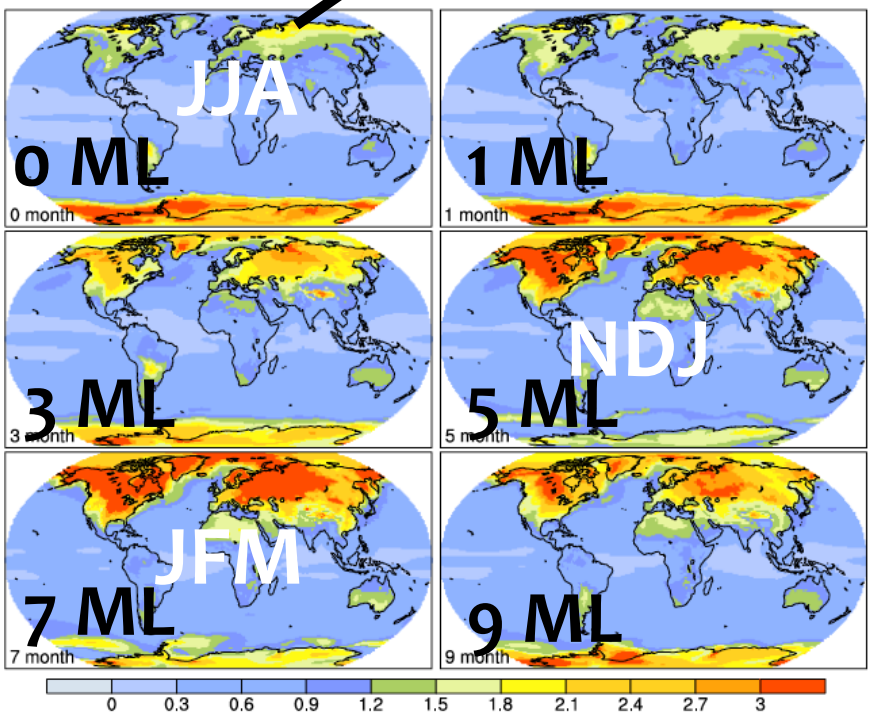


Seasonality in forecast standard deviation

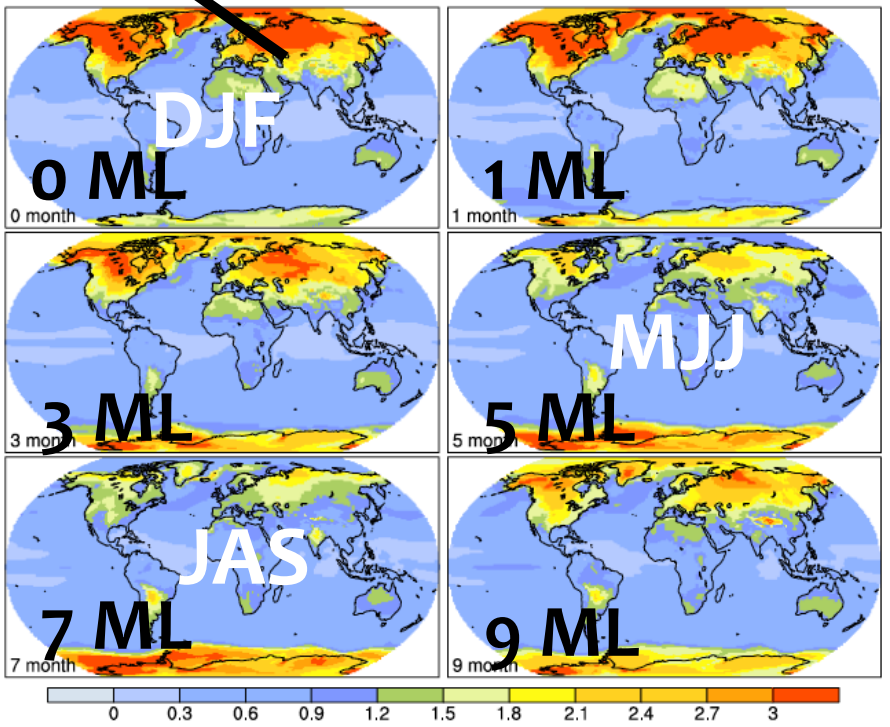
Forecast standard deviation across 24 members, averaged for 1982 to 2008



ML – Month Lead



Forecast initialized in JJA



Forecast initialized in DJF

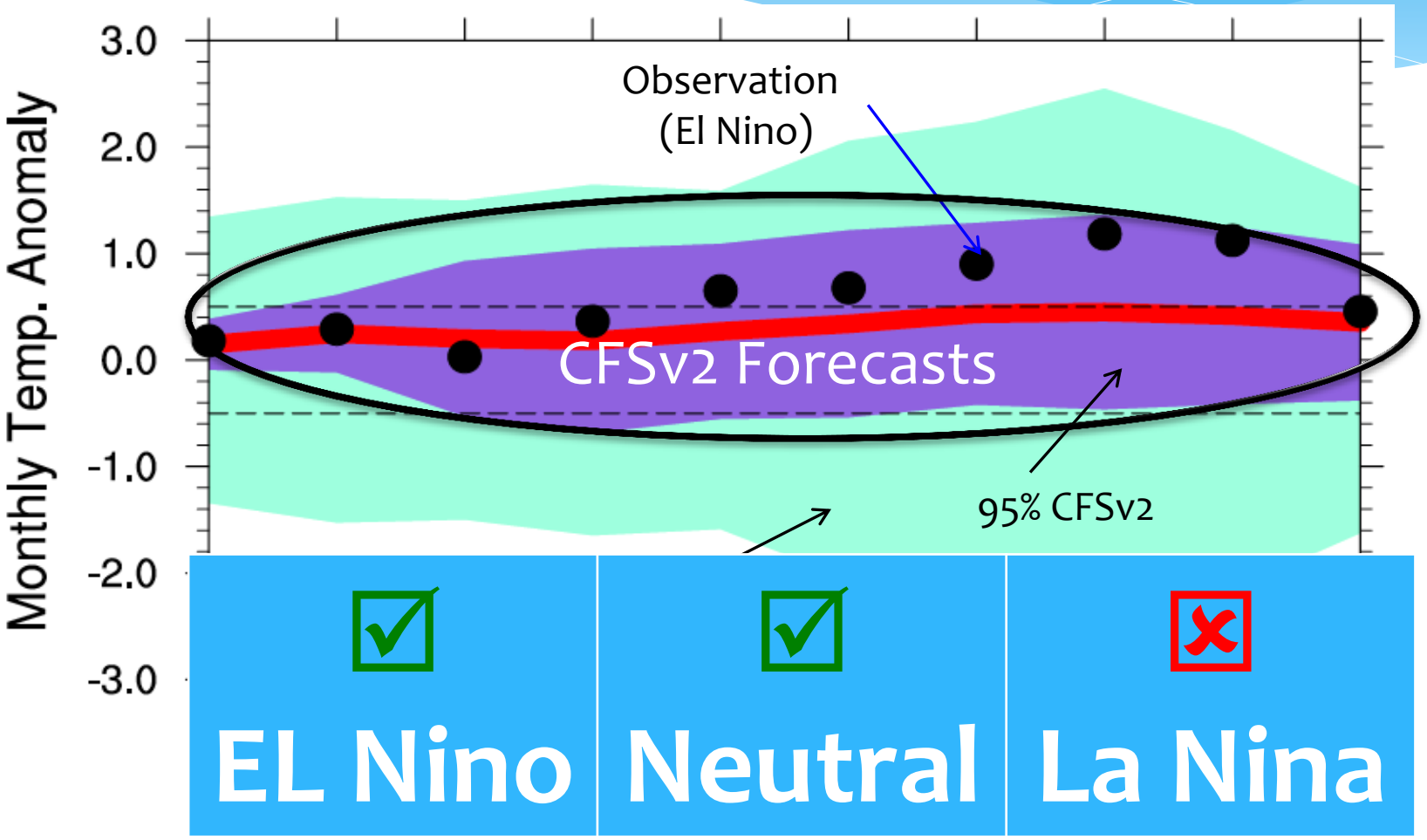
Conclusion

1. Removal of Systematic Error, a function of forecast initialization month and lead time, is necessary to bring the forecast in "the acceptable range"

2. Observations are randomly distributed around ensemble mean: a white noise with mean = 0, and standard deviation = ensemble standard deviation (H0 is not rejected)

3. CFSv2 provides useful ensemble forecasts (mean and standard deviation) at all forecasts lead (0 to 9 months).

Recommendation



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